February 24, 2004

Ms. Kathleen Johnson
Department of Environmental Quality
PO Box 200901
Helena, MT 59620-0901

Subject: CR Kendall Mine Closure Environmental Impact Statement
Hydrogeologic Data Summary Technical Memorandum

Dear Kathy:

Camp Dresser & McKee, Inc. (CDM) is pleased to submit to the Department of Environmental Quality (DEQ) 4 copies of the Final CR Kendall Mine Closure Environmental Impact Statement Hydrogeologic Data Summary Technical Memorandum.

Please contact me at (406) 449-2121 if you have any questions with regard to this report. CDM appreciates the opportunity to work with DEQ on this project.

Very truly yours,

Darrel M. Stordahl, P.E.
Principal/Senior Project Manager
Camp Dresser & McKee, Inc.

Environmental Impact Statement CR Kendall Mine Closure Fergus County, Montana

Technical Memorandum Hydrogeologic Data Summary

February 24, 2004

Final

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Section 1
Introduction

The Canyon Resources (CR) Kendall Mine is located approximately 7 miles west of Hilger, Montana in Fergus County, Montana. The mine has been inactive since 1995 and ore processing stopped in 1998. To complete the closure process for the CR Kendall Mine, an environmental impact statement (EIS) is being prepared to evaluate closure alternatives. The Montana Department of Environmental Quality (DEQ) has contracted CDM, Inc. (CDM) to complete the closure EIS. Tetra Tech EM, inc. (Tetra Tech) is a subcontractor to CDM, Inc. providing technical expertise in specific areas such as hydrogeology and mine reclamation in support of the EIS. This technical memorandum was prepared to provide an overall review of existing hydrogeological data and the results of site inspections conducted by CDM and Tetra Tech for the mine site and adjoining properties in July and August 2003.

Section 2
Objectives

Technical evaluations associated with the closure EIS process were guided by public input received during public and technical working group meetings conducted in Lewistown, Montana. A significant concern that was identified during the meetings was the impact of the mining operation on the quality and availability of groundwater, primarily springs and seeps, and ephemeral surface water flows in the major drainages down slope (east and south) of the mine property. A general request was made that the closure EIS team reevaluate existing hydrogeologic data and conduct site inspections to evaluate potential mining related impacts. A specific request was also made to prepare hydrogeologic cross-sections for each major drainage that crosses or originates on the mine site.

This technical memorandum presents the results of the review of existing hydrogeologic data and the July 23 and August 7, 2003 inspection and sampling activities conducted by CDM and Tetra Tech. Hydrogeologic information will be considered for the closure EIS alternatives for the mine disturbance area including the three waste rock repositories emplaced by recent (post 1981) mining activities, the open mine pits, and the groundwater pump-back system that is recovering groundwater from Little Dog Creek, Barnes King Creek, North Fork of Last Chance Creek (Mason Canyon), and the South Fork of Last Chance Creek. The pump-back system water is used for spray irrigation on revegetated portions of the mine site.

Section 3
Site Inspections

Site inspections were conducted on July 23-24 and August 7, 2003 by personnel from CDM and Tetra Tech. Activities conducted on the July 23-24 inspection included collection of waste rock and top soil stockpile samples, collection of filtered water samples from the Section 29, Kendall Townsite #2, and Ruckman Springs, pump-back system collector wells, and the Boy Scout Pond. Sediment samples were also collected from the Boy Scout, Ruckman, and Harron ponds south of the mine site. General water quality parameters (pH, Specific conductivity, and temperature) were recorded from a calibrated Horiba U-22 water quality meter at water sampling locations.

Activities on the August 4 site inspection consisted of a tour of spring, pond, and piezometer sites in the Little Dog Creek and Dog Creek drainages located on the Schammel Ranch property east and northeast of the Kendall mine. Brian Goodman of Tetra Tech was accompanied by Dave Erickson of Water & Environmental Technologies (WET) and Wayne Jepson of DEQ. Additional waste rock and topsoil samples were collected from the July 23-24 sampling sites for geotechnical analysis. These samples were delivered to Maxim Technologies in Helena, Montana for analysis.

Section 4
Geology and Hydrology of the CR Kendall Mine Area

The principal documents reviewed for hydrologic and geologic information on the CR Kendall Mine and adjacent areas included *Flowpath Evaluation for the C.R. Kendall Mine Area, Fergus County, Montana,* (Gallagher 2002) and *Evaluation of Background Hydrochemistry for the Kendall Mine,* (Water Management Consultants, Inc. (WMCI) 1999). Geologic and topographic maps were also obtained from CR Kendall Mine records and were used to construct hydrogeologic cross-sections along principal drainages that originate in the mine area. The local hydrogeology of these drainages is discussed individually in Section 5.

4.1 Geology

The geology and mineral deposits of the North and South Moccasin Mountains were evaluated by Lindsey (1982) and describes the area as dominated by Tertiary lacolith intrusions of syenite and quartz monzonite porphyry mantled by older Paleozoic and Mesozoic sedimentary rocks. The Paleozoic and Mesozoic formations are steeply dipping on the flanks of the intrusions with decreasing dips away from the mountains. Dips of the Madison Limestone can be observed in the Muleshoe pit (Photo 1). Mineralization at the CR Kendall mine on the west flank of the North Moccasin Mountains was initially exploited in the late 1800s. The primary ore zone was an oxidized silicified limestone breccia at the top of the Madison Limestone emplaced along a north-south trending normal fault (down to the east). The generalized stratigraphy of the Kendall Mine area is summarized in Table 1.

Table 1
Generalized Stratigraphy CR Kendall Mine Area

Unit	Age	Lithology	Thickness	Water-Bearing Properties (after Feltus 1973)
Historic Mine Tailings	Recent	Sand, silt and clay sized mill tailings	Variable 0-55 ft.	Unknown, may be saturated in some areas
Colluvium/Alluvium (Qal)	Quaternary and Pleistocene	Unconsolidated gravel, sand, silt, and clay deposits in ephemeral stream channels and adjacent valleys	Variable, generally increasing east of the mine site	Yields to wells and springs, adequate for domestic and stock watering
Syenite (Ts)	Paleocene	Primarily Syenite, other igneous rock types occur in associated sills and dikes	Unknown	Variable yield of groundwater in seeps and springs where fracture permeability present
Kootenai (Kk)	Lower Cretaceous	Sandstone, siltstone, and limestone	520 ft	Sandstone is used as an aquifer south of the Moccasin Mountains
Morrison (Jm)	Upper Jurassic	Claystone, siltstone, sandstone, and limestone, thin coal and/or carbonaceous shale occurs near the top of the formation	200 ft.	Some mine monitoring wells completed in the Morrison (TMW-20, 25 gpm, TMW-30, n/a)
Swift (Js)	Upper and Middle Jurassic	Claystone, siltstone, and sandstone	60-125 ft.	Yield to wells near Lewistown where composed predominantly of sandstone, some mine and water supply wells completed in the Swift.
Rierdon and Piper (Jrp)	Middle Jurassic	Shale and thin bedded limestone	285-345 ft.	Not a regional aquifer, but may produce water where fracture porosity is developed, some mine water supply wells (WW-3, WW-6, WW-7) completed in Rierdon and Piper formations.
Kibbey (Mk)	Upper Mississippian	Iron stained sandstone, siltstone, and shales	60-80 ft.	Potential aquifer
Madison Group (Mm)	Lower Mississippian	Medium to massive bedded limestone and dolomitic limestone, brecciated zones present at CR Kendall Mine	>1000 ft.	Potential aquifer if secondary solution channels and collapse breccias present.

4.2 Hydrology

4.2.1 Surface Water

The North Moccasin Mountains reach an elevation of over 5,700 feet, and lie on a drainage divide between the Judith and Missouri River Basins. Surface water in the CR Kendall Mine area is primarily composed of runoff of snowmelt and storm water in ephemeral drainages, some of which also receive supplemental flow from groundwater discharge (springs). The majority of surface flow from the upper portion of the North Moccasin Mountains watershed is intercepted by porous and possibly karstic Madison Limestone and little or no runoff reaches lower sections of the drainages.

WMCI (1999) evaluated surface water monitoring data for the mine site from seven surface water monitoring stations established in 1982 (KVSW-1 through KVSW-7). Instantaneous flow measurements for the period indicated an average flow of 0.1 to 6.7 gpm. The maximum flow was 76.3 gpm recorded in the South Fork of Last Chance Creek at station KVSW-5. In general, the stations had maximum flow in the Spring months declining over the summer to little or no flow in the Fall months. Continuous flow measurements over several months were only available in the southern drainages. Analysis of one storm event in August 1996 indicated little groundwater recharge (gain) in the drainages from the storm event. WMCI reported that no surface water was observed in the drainages above the mine in the North Moccasin Mountains and that flows above the mine are lost as recharge into the Madison Limestone. This was also observed during a site inspection on June 2003 downstream of Little Dog Spring where all surface flow is lost in the drainage at the Madison Limestone contact with the Synenite Porphyry (See Section 5 for additional discussion of Little Dog Spring).

Photo1
South Side of Muleshoe Pit, CR Kendall Mine view looking south at steeply east dipping beds of Madison Limestone, June 2, 2003.

Gallagher (2002) documented drought conditions that have persisted in the area for the last decade. The average precipitation reported for the Kendall Mine site for 1992 to 2001 was 22.36 inches. The majority of annual precipitation occurs in May, June, and July. The cumulative precipitation deficit for the period ranged from 0.17 to 6.03 inches and closely reflects precipitation patterns from other weather stations in the Fergus County area. Hydrologic drought, such as declining groundwater levels due to decreased recharge and increased evapotranspiration are likely a major contributing factor in decreased spring and ephemeral stream flows reported in the drainages originating on or crossing the mine site.

4.2.2 Groundwater

Groundwater has not been encountered during recent (post 1981) mining operations at CR Kendall. All mine pits are dry and indicate that mining did not intercept the water table in the Madison Limestone and adjacent limestone breccia formation. In addition, no historical evidence of groundwater discharge from historical underground workings was reported in the available literature. Historical mining operations and the town of Kendall obtained water supply from springs located above the mine and from Warm Springs located approximately four miles to the south.

Groundwater discharges (springs and seeps) are present above and below the CR Kendall mine site. The spring with the largest discharge is Little Dog Spring located in the upper portion of the Little Dog Creek drainage above the mine workings at an altitude of 4,740 feet. Little Dog Spring appears to originate from a fracture flow system in the Tertiary Syenite Porphory that was intercepted by erosional downcutting of the Little Dog drainage. No gauging of this spring has been conducted. A portion of the Little Dog Spring discharge is piped to the stock tank at the Section 29 Spring at an elevation of approximately 4,360 feet. This diversion is conducted seasonally in the spring and summer months to supplement flows in Little Dog Creek which are used for livestock watering. Section 29 Spring has reportedly gone dry during winter months.

Springs located in the drainages east of the mine site appear to be related to low permeability units in the bedrock aquifers (Morrison and Kootenai Formations) in combination with groundwater movement in the alluvial aquifer sediments. These type of springs are highly susceptible to small fluctuations in water table elevation and result in variable seasonal discharge. Fluctuations in water table elevation may be the result of several factors alone or in combination including increased groundwater withdrawal, seasonal recharge variations, decreasing recharge from precipitation due to drought, and increased evapotranspiration.

Other small discharge springs (seeps) appear to be associated with discharge from low permeability bedrock units of the Morrison Formation which perch infiltrating groundwater and direct it laterally to seepage faces in excavation cuts and on slopes. WMCI (1999) indicated that most of the water in the seeps is derived from local recharge sources or in some cases as seepage from mine facilities.

4.2.3 Mine Pump-Back, Monitoring, and Water Supply Wells

CR Kendall mine has installed numerous monitoring wells that date back to 1985. Most wells are located in the vicinity of the groundwater pump-back system or are located in the process valley to monitor the heap leach operations. In general, existing well data do not allow for evaluation of the capture efficiency of the pump-back system collector wells.

A summary of the mine site monitoring and water supply wells is presented in Tables 2 and 3 respectively. All monitoring wells are less than 100 feet deep and are screened in the shallow alluvium or into the first bedrock formation encountered.

Eight water supply wells are present at the mine site. WW-6 and WW-7 are used to augment surface flows in the South Fork of Last Chance Creek (Mason Canyon) and in Little Dog Creek drainages respectively. Well log information indicated that both wells are completed in the Rierdon and Piper formations. Recent information from mine personnel indicate that the static water levels in WW-6 and WW-7 were near or above the ground surface in the spring of 2003.

Section 5
Drainage Descriptions

The following sections describe and discuss the hydrogeologic data for each major drainage that crosses or originates at the CR Kendall mine site. An index map (Figure 1) and cross-sections along each drainage are attached as Figures 2 through 7.

5.1 Dog Creek

Dog creek is located on the northeast flank of the North Moccasin Mountains. A minor portion (approximately 2 acres) of the mining disturbed area lies within the Dog Creek drainage. Anecdotal information from the adjacent ranch owners indicate that surface and spring flows have decreased in the drainage and they have installed a pipeline above the Madison Limestone exposure to transport groundwater from the drainage headwater area to augment flows for livestock lower in the drainage. WET, a groundwater consultant for the ranch owners, has installed several shallow 1-inch diameter piezometers in the alluvium near springs and seeps in Dog Creek drainage.

During the August site inspection, WET personnel stated that drawdown had been observed in the piezometers in response to pumping from WW-7. Gallagher (2002) evaluated possible indirect impacts from water well pumping on spring discharges in Dog Creek; however there is an overall lack of monitoring data for the bedrock aquifers. The extreme east dip of bedrock units combined with pumping may result in an elongated north-south potentiometric cone of depression that may span surface drainage divides.

5.2 Little Dog Creek

Little Dog Creek is located south of Dog Creek and was bisected by recent mining operations. In the headwaters area in the North Moccasin Mountains on BLM property is a relatively large spring known as Little Dog Spring (Photo 2). The spring apparently discharges from fractured Tertiary Syenite and the flow is reported to be perennial although no gauging records are available. As previously mentioned, a portion of the spring flow is piped to the Section 29 Spring to augment flow below the mine groundwater pump-back system. No surface flow has been reported in the

Table 2
Summary of CR Kendall Monitoring Well Completion and Lithology Information

Well No.	Date Installed	Casing Size/Type	Static Water Level (ft below top of casing)	Lithology	Total Depth (feet below ground surface)	Screened Interval (feet below ground surface)
TMW-3A	12/5/85	4" PVC	dry	Tailings 0-20"; soil & clay 20-22	22	17-22
TMW-3B	12/22/85	4" PVC	48'	0-20 tails; topsoil & clay 20-22; gravel 22-44; dark gray-green sandstone, 44-50	50	40-50
TMW-4	No date	4" PVC	n/d	0-8 tailings; 8-19 topsoil; 19-60 yellow and gray sandstone	60	30-60
TMW-4B	7/9/89	4" PVC	dry	0-10 tails; 10-30 orange-black clays; 30-45 Swift Formation with intrusive dike	45	19-45
TMW-5A	12/4/85	4" PVC	54	0-20 tailings; 20-60 gravel & gravel with clay and green shale; sandstone 60-75	75	65-75
TMW-6	12/5/85	4" PVC	49	0-5 gravel; 5-20 clay; 20-23 gravel; 23-59 brown, green sandstone	59	49-59
TMW-7	12/5/85	4" PVC	32	0-10 green-gray shale; 10-20 dark green shale; 20-28 black shale; 28-38 dark green shale	38	28-38
TMW-8	12/20/85	4" PVC	dry	0-55 tailings; 55-88 gravel; 88-90 gravel & sandstone; 90-95 brown sandstone	95	85-95
TMW-8B	7/7/89	4" PVC	48.39	0-50 gravel & limestone, silts 50-51 limestone	51	25-51
TMW-9	12/5/85	4" PVC	34	0-5 dark brown clay; 5-17 green gray shale; 17-22; dark green shale; 22-34 black shale; 34-40 green & brown sandstone	40	30-40
TMW-10	12/5/85	4" PVC	50	0-40 gravel; 40-50 dark green sandstone; 50-60 green sandstone and black shale	60	50-60
TMW-11	6/6/87	4" PVC	26	0-5 tailings; 5-15 soil; 15-44 sand; 44-58 siltstone green-brown	58	32-53
TMW-12	7/7/89	4" PVC	dry	0-15 brown-black clay; 15-35 clay siltstone; 35-40 Swift Formation	40	15-40
TMW-13	7/7/89	4" PVC	62.16	0-34 tailings & gravel; 34-95 Swift Formation	95	55-95
TMW-14	7/8/89	4" PVC	12.3	0-55 tailings, clay, gravel; 55-56 Swift Formation	56	24-56
TMW-15	7/8/89	4" PVC	dry	0-18.5 tailings, clay, gravel; 18.5-19 Madison Limestone	19	10-19
TMW-15B	No data	4" PVC	No data	No data	45.15	No data
TMW-16	7/8/89	4" PVC	dry	0-32 gravels, clays; 32-33 Swift Formation	33	13-33
TMW-17	7/8/89	4" PVC	dry	0-23 clays, silts; 23-24 Swift Formation	24	10-24
TMW-18	12/4/89	4" PVC	19	0-21 clay, tailings; 21-25 Swift Formation	25	13.25
TMW-19	11/29/89	4" PVC	25	0-55 silts, clays, gravel; 55 Swift Formation	55	36-55

Source : Gallagher (2002)

Table 2 (Continued)
Summary of CR Kendall Monitoring Well Completion and Lithology Information

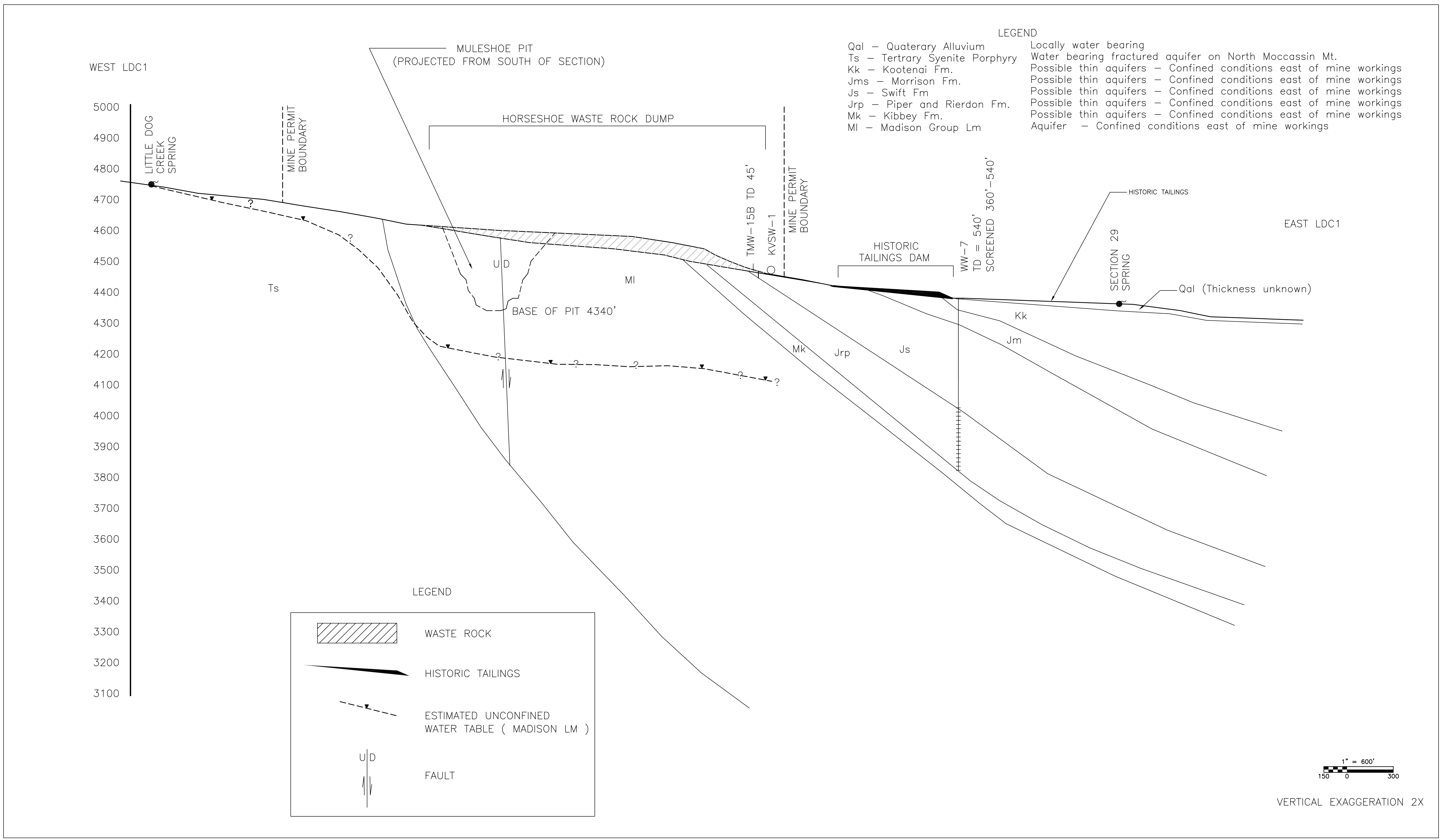
Well No.	Date Installed	Casing Size/Type	Static Water Level (ft below top of casing)	Lithology	Total Depth (feet below ground surface)	Screened Interval (feet below ground surface)
TMW-20	No data	4.5" PVC	16.6	0-30 tailings; 30-55 alluvium; 55-80 Morrison Formation; 80-85 Swift Formation	85	72-85
TMW-21	No data	4.5" PVC	17.18	0-5 tailings; 5-56 alluvium	56	19-56
TMW-24	11/28/89	No data	6	0-10 black clay; 10-35 alluvium; 35-39 Swift Formation	39	15-39
TMW-24B	No data	No data	No data	No data	28.3	No data
TMW-27	12/1/89	No data	53	0-30 tailings, clays; 30-84 Swift Formation	84	No data
TMW-28	11/30/89	4" PVC	57	0-25 tailings; 25-59 alluvium; 59-61 Swift Formation	61	27-61
TMW-29	11/30/89	4" PVC	60	0-20 tailings; 20-30 alluvium; 30-75 Swift Formation	75	45-75
TMW-30	12/1/89	4" PVC	23	0-5 tailings; 5-7 clay; 7-21 alluvium; 21-23 Morrison Formation	23	12-23
TMW-30A	No Data	No data	No Data	Alluvium	20	No data
TMW-31	12/4/89	4" PVC	7	0-11 clay & gravel; 11-13 Syenite	13	5-13
TMW-32	12/3/91	4.5" PVC	no data	0-57 colluvium, gummy clays; 57-63.5 Swift Formation	63.5	12-63.5
TMW-33	12/4/89	4.5" PVC	no data	0-73 colluvium, gummy clays; 73-78 Swift Formation	78	12-78
TMW-34	12/4/89	4.5" PVC	no data	0-58 colluvium, gummy clays; 58-65 Swift Formation	65	12-65
TMW-35	12/5/89	4.5" PVC	no data	0-55 colluvium, gummy clays; 55-60 Swift Formation	60	12-60
TMW-36	No log available			alluvium & top of Morrison Formation	32	No data
TMW-37	No log available			Alluvium	27	No data
TMW-38	No log available			Alluvium	32	No data
TMW-39	No log available			Alluvium	37	No data
TMW-40D	No log available			alluvium & Morrison Formation	37	No data
TMW-40S	No log available			alluvium & Morrison Formation	19	No data
TMW-42	No log available			alluvium & Morrison Formation	29	No data
TMW-43	No log available					
TMW-44	No log available					
TMW-45	No log available					

Source : Gallagher (2002)

Table 3
Summary of CR Kendall Water Supply Well Completion and Lithology Information

Well No.	Date Installed	Casing Size/Type	Static Water Level (feet below top of casing)	Geology	Total Depth (feet below ground surface)	Screened Interval (feet below ground surface)
WW-1	5/5/88	No data	438	0-25 gravels; 25-185 Swift Formation; 185-345 Syenite Intrusion; 345-438 Rierdon Formation	438	60-100; 330-370; 400-438
WW-2	6/23/88	6"	No data	0-80 alluvium; 80-240 Swift Formation; 240-355 Rierdon Formation; 355-385 Syenite	385	No data
WW-3	7/11/88	No data	No data	0-20 no sample; 20-110 Morrison Formation; 110-270 Swift; 270-360 Rierdon Formation; 360-430 Syenite; 430-450 Rierdon Formation ; 450-470 Piper Formation	470	285-470
WW-4	7/21/88	No data	No data	0-5 tailings; 5-275 gray sandstone, shale, siltstone; 275-285 Swift Formation	285	No data
WW-5	No log					
WW-6	2/24/92	8" steel	Varies from near surface to artesian	0-32 red & brown gummy clay; 32-180 clays; 180-261 sandstone; 261-341 salt & pepper sandstone: 341-375 limestone; 375-392 shale; 392-431 sandstone; 431-490 ratty limestone	490	342-490
WW-7	9/12/92	8 5/8" steel	Varies from near surface to artesian	0-45 Kootenai Formation; 45-80 Morrison Formation; 80-360 Swift Formation; 360-540 Rierdon-Piper Formation	540	360-540
WW-9	7/15/88	4"(?)	No data	0-5 no sample; 5-145 Morrison Formation; 145-275 Swift Formation; 275-380 Rierdon Formation; 380-465 Piper Formation	465	No data

Source : Gallagher (2002)



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CDM

Figure 1
Hydrogeological Cross-Section Little Dog Creek

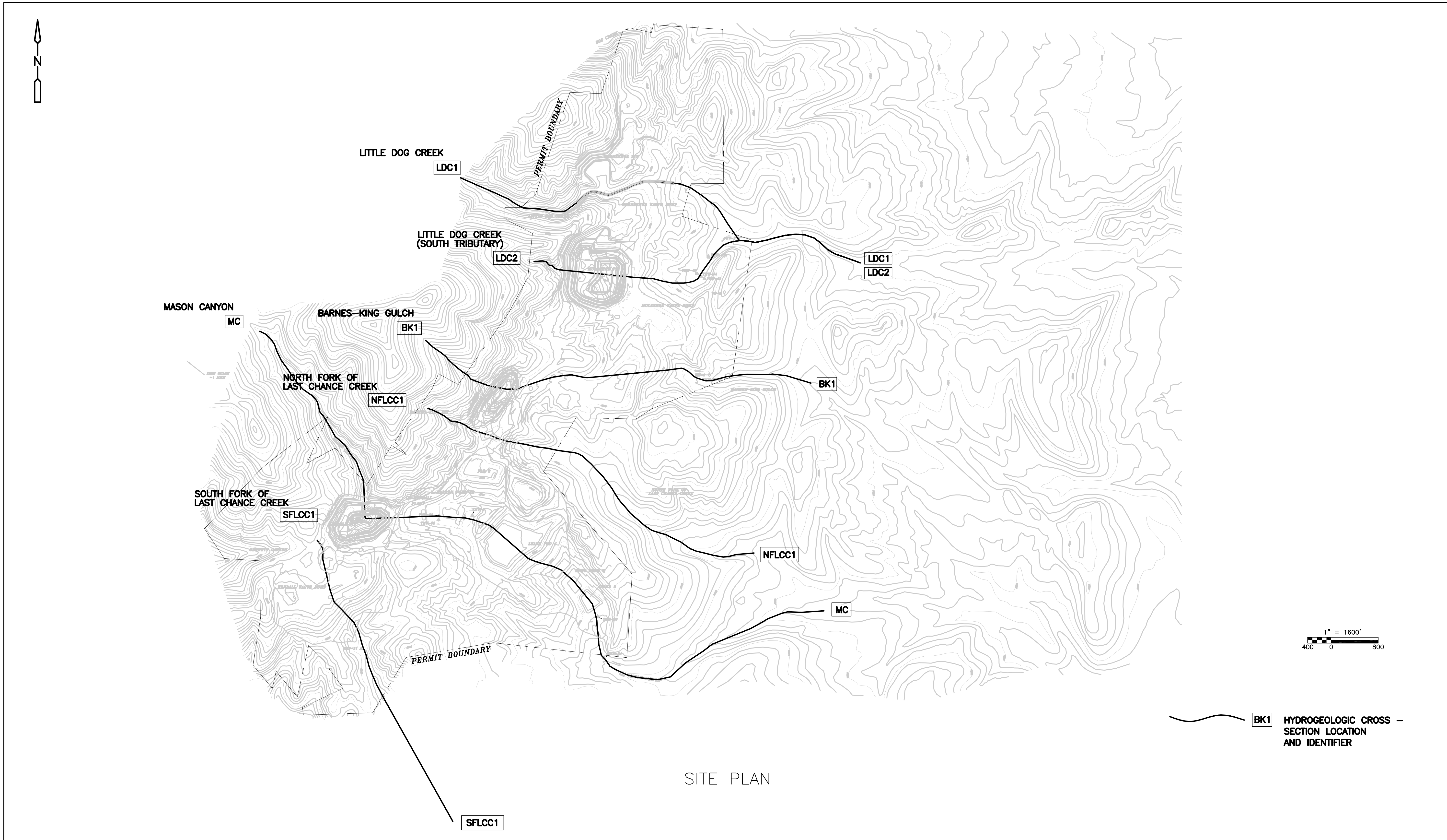

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Figure 2
Kendall Mine Cross Section Locations

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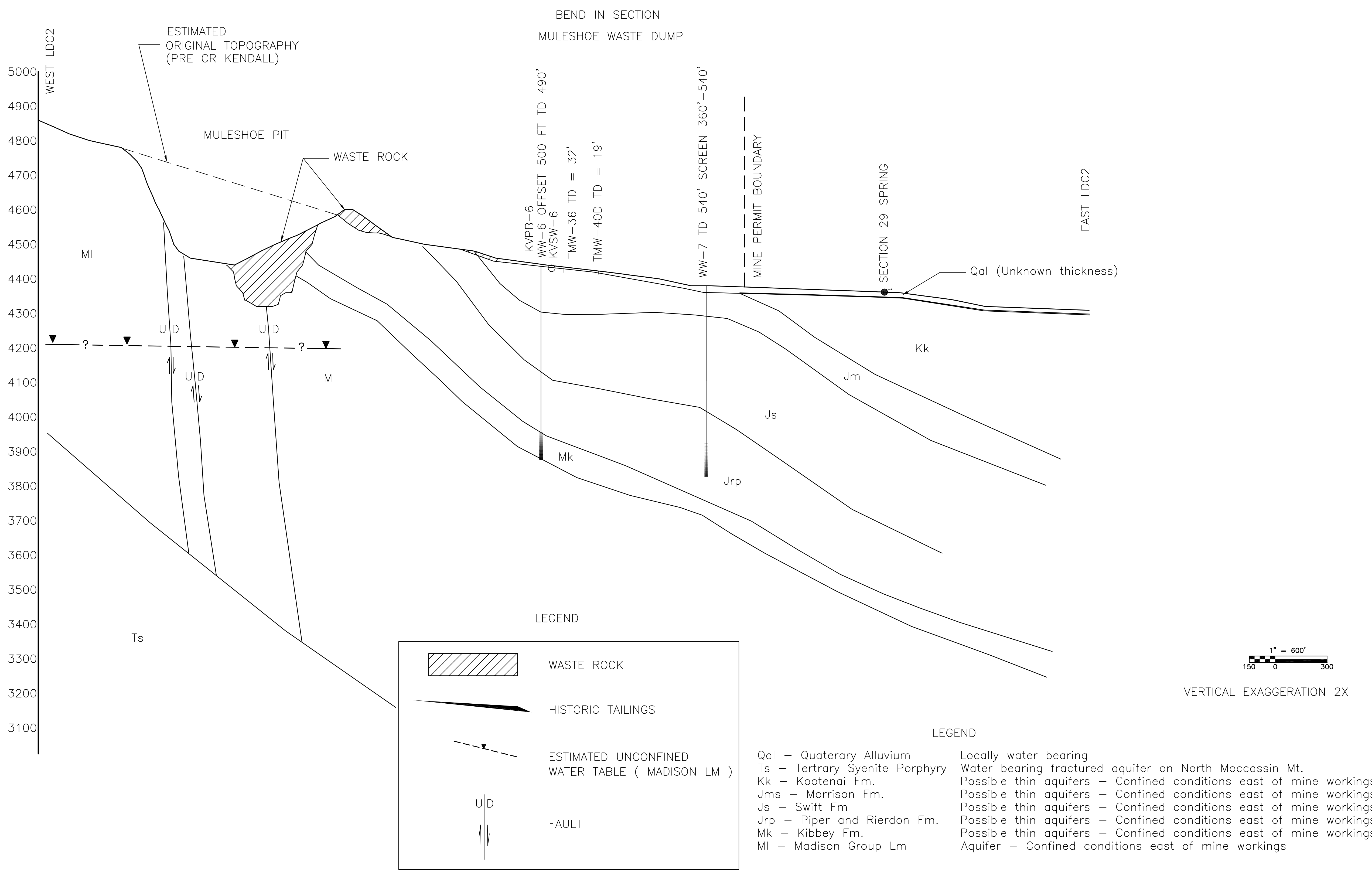

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Figure 3
Hydrogeological Cross–Section Little Dog Creek 2

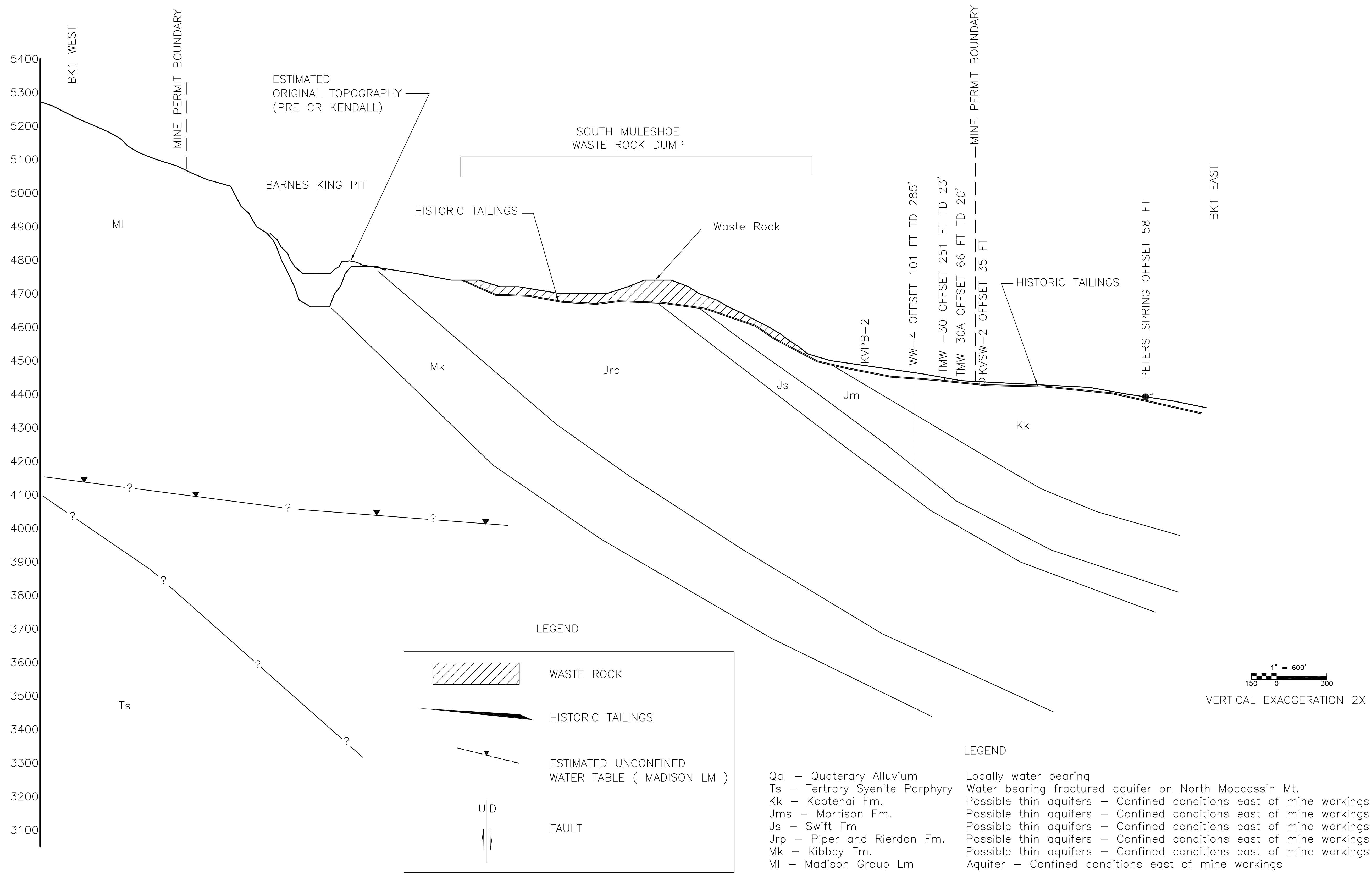

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Figure 4
Hydrogeological Cross–Section Barnes King 1

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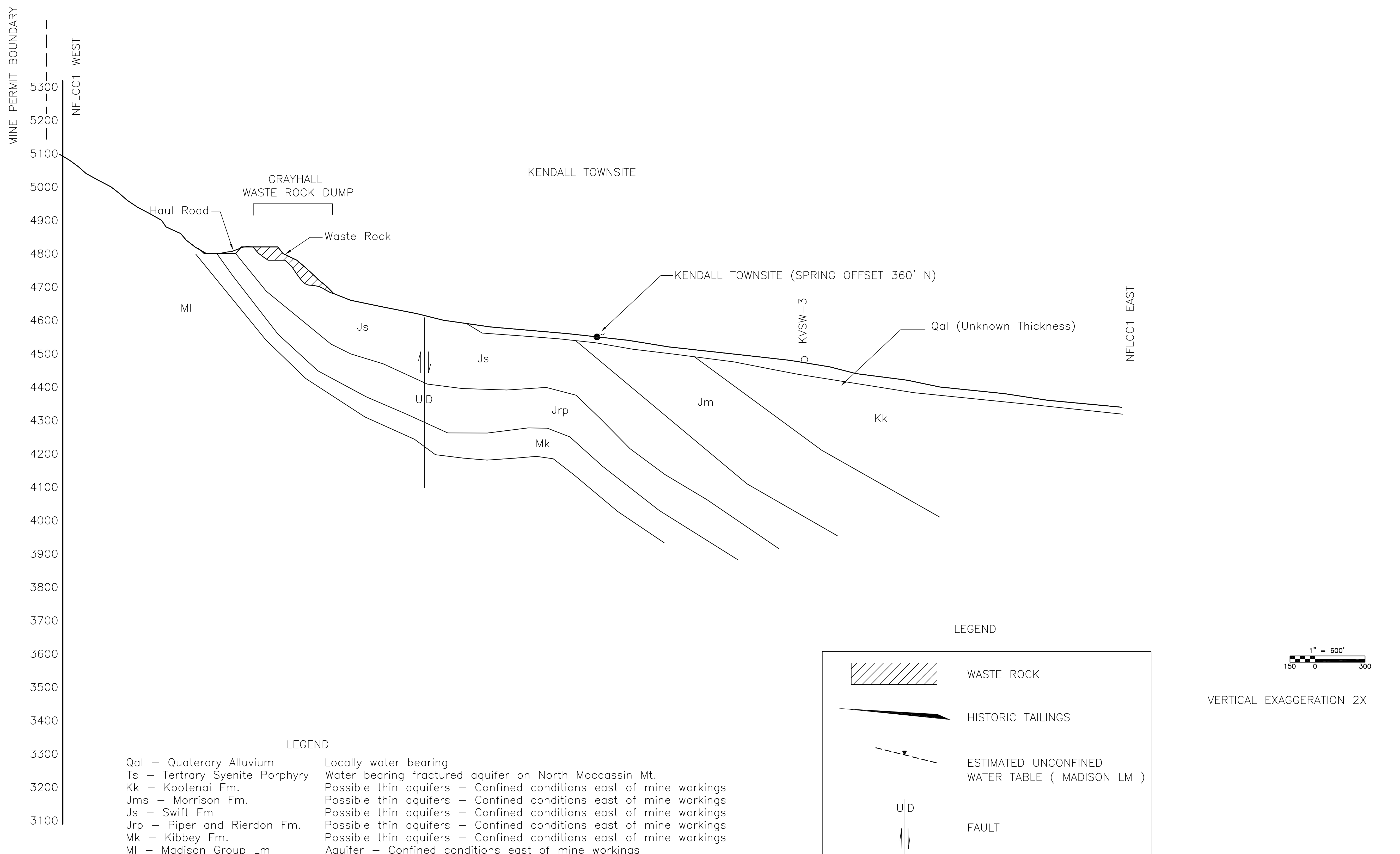

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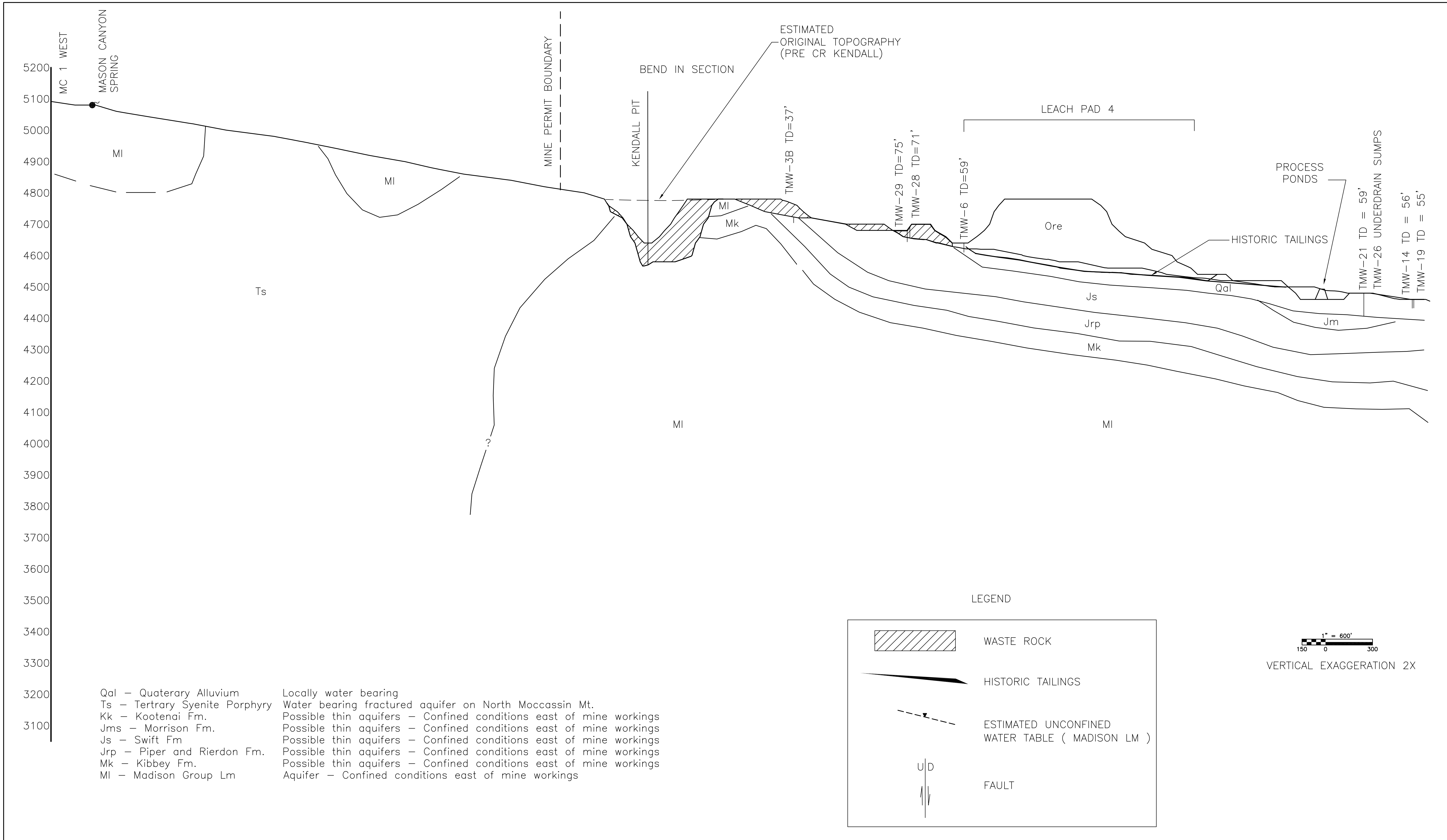
Figure 5
Hydrogeological Cross–Section North Fork Last Chance Creek



Qal – Quaterary Alluvium	Locally water bearing
Ts – Tertrary Syenite Porphyry	Water bearing fractured aquifer on North Moccassin Mt.
Kk – Kootenai Fm.	Possible thin aquifers – Confined conditions east of mine workings
Jms – Morrison Fm.	Possible thin aquifers – Confined conditions east of mine workings
Js – Swift Fm	Possible thin aquifers – Confined conditions east of mine workings
Jrp – Piper and Rierdon Fm.	Possible thin aquifers – Confined conditions east of mine workings
Mk – Kibbey Fm.	Possible thin aquifers – Confined conditions east of mine workings
Ml – Madison Group Lm	Aquifer – Confined conditions east of mine workings

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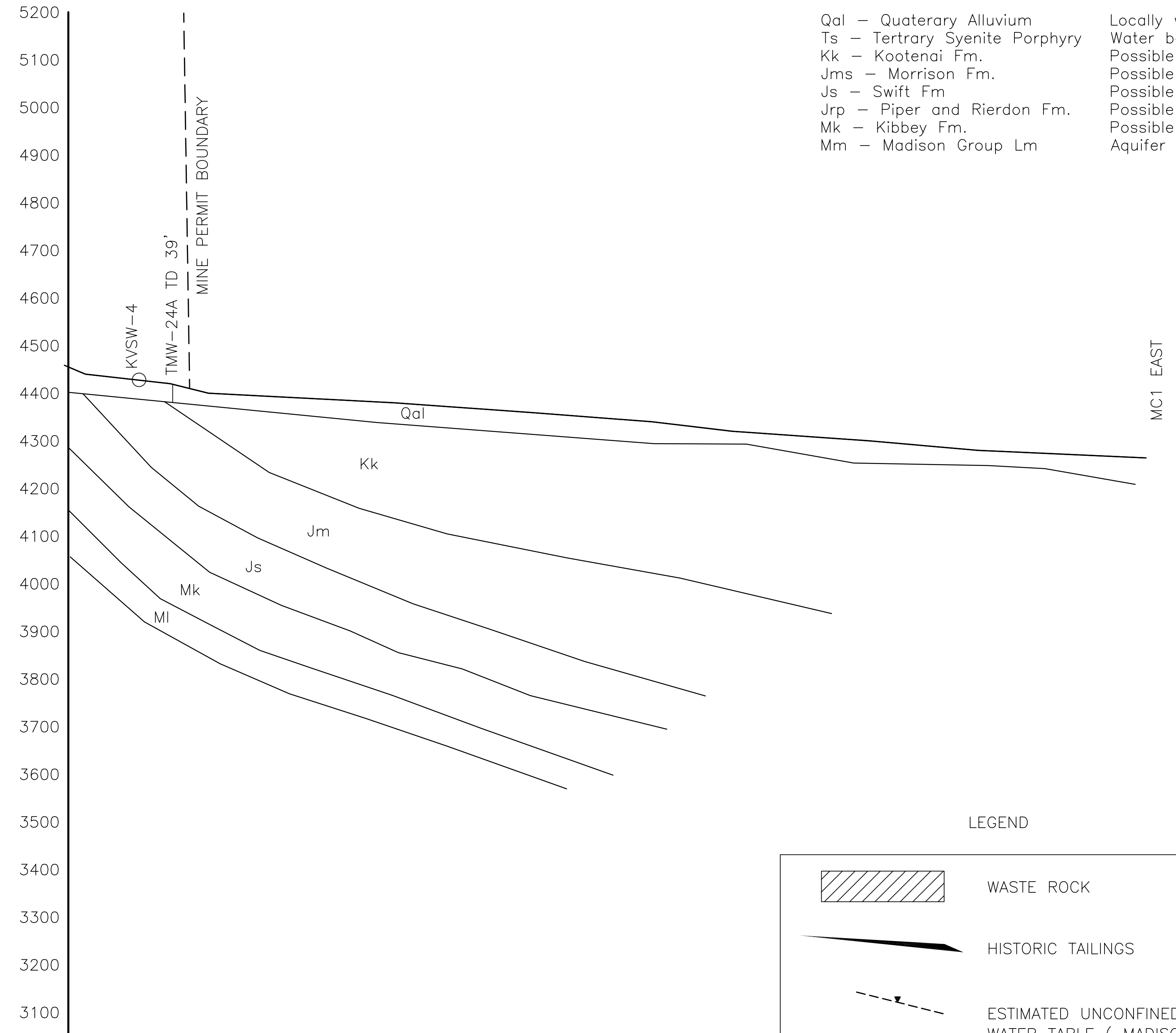
Figure 6
Hydrogeological Cross-Section Mason Canyon Process Valley Sheet 1 Of 2



LEGEND

Qal – Quaterary Alluvium	Locally water bearing
Ts – Tertrary Syenite Porphyry	Water bearing fractured aquifer on North Moccassin Mt.
Kk – Kootenai Fm.	Possible thin aquifers – Confined conditions east of mine workings
Jms – Morrison Fm.	Possible thin aquifers – Confined conditions east of mine workings
Js – Swift Fm	Possible thin aquifers – Confined conditions east of mine workings
Jrp – Piper and Rierdon Fm.	Possible thin aquifers – Confined conditions east of mine workings
Mk – Kibbey Fm.	Possible thin aquifers – Confined conditions east of mine workings
Mm – Madison Group Lm	Aquifer – Confined conditions east of mine workings

LEGEND

WASTE ROCK

HISTORIC TAILINGS

ESTIMATED UNCONFINED
WATER TABLE (MADISON LM)

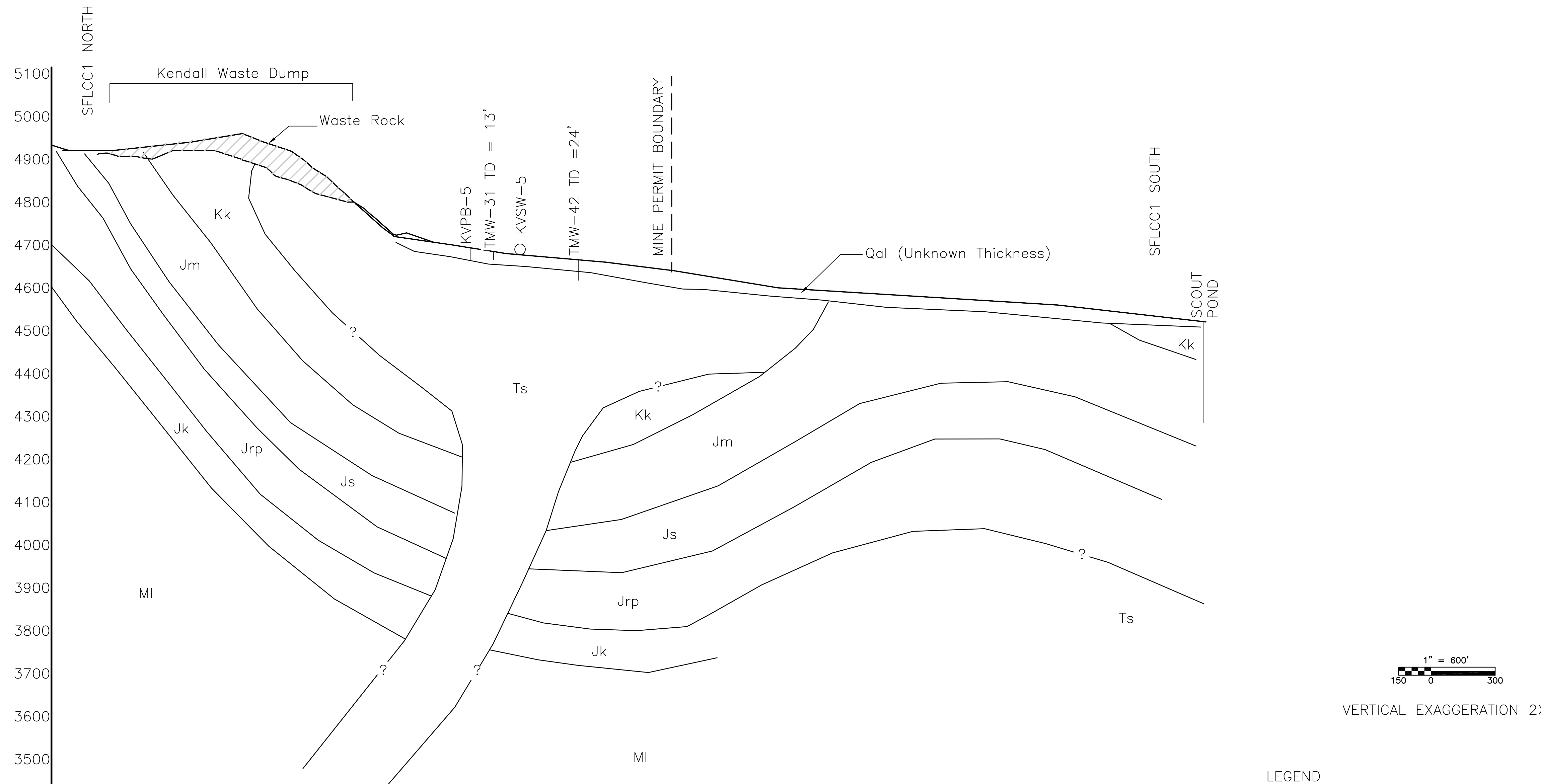
U D
FAULT

1" = 600'
150 0 300

VERTICAL EXAGGERATION 2X

CDM

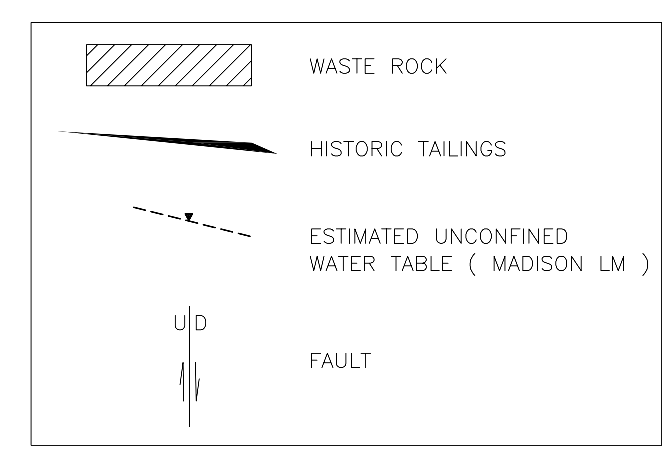
Figure 6
Hydrogeological Cross–Section Mason Canyon Process Valley Sheet 2 Of 2



LEGEND

Qal – Quaterary Alluvium	Locally water bearing
Ts – Tertrary Syenite Porphyry	Water bearing fractured aquifer on North Moccassin Mt.
Kk – Kootenai Fm.	Possible thin aquifers – Confined conditions east of mine workings
Jms – Morrison Fm.	Possible thin aquifers – Confined conditions east of mine workings
Js – Swift Fm	Possible thin aquifers – Confined conditions east of mine workings
Jrp – Piper and Rierdon Fm.	Possible thin aquifers – Confined conditions east of mine workings
Mk – Kibbey Fm.	Possible thin aquifers – Confined conditions east of mine workings
Ml – Madison Group Lm	Aquifer – Confined conditions east of mine workings

LEGEND



CDM

Figure 7
Hydrogelogical Cross Section South Fork Last Chance Creek

Little Dog Creek drainage entering the mine due to infiltration into the Madison Limestone which occurs approximately 1,000 feet west of the mine on BLM property. Brief surface flows may occur in the early spring months where heavy runoff combined with frozen ground conditions may allow for surface flow across the Madison Limestone outcrop to the mine site.

The Little Dog Creek drainage within the mine permit boundary is obscured as a result of the excavation of Horseshoe pit, the backfilled South Horseshoe pit, and two waste rock dumps. Historic tailings and waste rock also filled a portion of the drainage.

The south branch of the drainage, referred to as the Muleshoe Branch, contains three monitoring wells (TMW-36, TMW-40D, and TME-41S) and the collector well KVPB-6 which is part of the groundwater pump-back system. Monitoring data indicate that the shallow groundwater quality has been impacted by mining operations. Water quality in bedrock supply wells appears to be good; however, no deep monitoring wells are present to evaluate bedrock hydrogeology and flow paths. Cross-sections of the Little Dog Creek Drainage are shown in Figures 2 (North Fork) and Figure 3 (South Fork).

Photo 2
Little Dog Spring Discharge Area. View looking west.
Spring collection box in center of photograph, June 2, 2003

5.3 Barnes-King Gulch

Barnes-King Gulch is located in the central mine area north of the Kendall Townsite and south of Little Dog Creek. It is the northernmost tributary to Last Chance Creek and contains a large volume of historic tailings. The headwaters area of the drainage is obscured by the South Muleshoe waste rock dump (Figure 4). Historic data from the mine indicate that the drainage terminated near the Barnes-King pit. The drainage contains two monitoring wells completed in the alluvium (TMW-30 and TMW-30A) and the pump-back collector well KVPB-2 (Photo 3). TMW-30 is not being monitored and is predominantly dry. Since installation of the pump-back system, surface flows at monitoring stations have decreased and the Peters Spring downstream of the pump-back collector well went dry.

Augmentation of flow in the Barnes-King drainage is not being conducted due to the presence of a large volume of historic tailings downstream of the mine permit boundary. Water supply well WW-4 is located in the Barnes-King drainage and is reportedly completed in the Swift Formation at 285 feet bgs. Water quality data from WW-4 will be obtained from CR Kendall. Flow and water quality in bedrock units in this Barnes-King Gulch area have not been evaluated.

Photo 3
Pumpback System Collector Well KVPB-2 and Barnes-King Gulch. View looking east, July 24, 2003

5.4 North Fork of Last Chance Creek

The North Fork of Last Chance Creek, also referred to as The Kendall Townsite drainage has a minor portion of its headwaters area within the disturbed area of the CR Kendall mine. The disturbed area includes a small waste rock dump generated by Grayhall Resources operations in the 1980s and the Barnes-King pit (Figure 5). No historic tailings have been observed in the drainage. WMCI (1999) described two spring sites in the drainage, one of which is piped and discharged into a stock tank south of the road. A seep located south of the townsite on a drainage divide between the Mason Canyon and North Fork of Last Chance Creek drainages was reported to have acid mine drainage characteristics (pH of 3 to 4) (WMCI 1999). An inspection of the seep indicated that the seeps originate at road excavations with exposures of coal and carbonaceous shale in the Morrison Formation. Oxidation of pyrite within the coal and carbonaceous shale can result in the observed low pH groundwater with relatively higher concentrations of heavy metals and sulfate.

There are no monitoring wells located in the Kendall Townsite drainage; however, the Peters well is located in the downgradient portion of the drainage. The well is reported to be shallow (less than 50 feet bgs) and completed in the alluvium. A small spring in the townsite (Kendall Spring) was sampled during the July site inspection and flow was estimated at 1-2 gallons per minute. WMCI (1999) reported that hydrochemical data for the Kendall Spring and other surface water monitoring sites in the drainage do not show significant mine related impacts. Flow and water quality in bedrock units in this area have not been evaluated.

5.5 Mason Canyon

The Mason Canyon headwaters area originates in the upper portion of the North Moccasin Mountains on BLM property. Similarly to Little Dog Creek, a spring is located above the mine permit boundary; however, mapping by Lindsey (1982) indicates that the spring (referred to as Mason Canyon Spring) originates from the Madison Limestone. Tertiary Syenite porphyry sill-like tongues or offshoots from the main syenite body are mapped in the area (Figure 6). These syenite offshoots may result in localized low permeability conditions that cause the surfacing of groundwater flow at Mason Canyon Spring. No gauging data are available for the Mason Canyon Spring; however mine personnel reported that evidence of historical development and use are present at the spring site.

The Mason Canyon drainage trends southeast from the spring and enters the Kendall pit. Mine personnel reported that surface flow from the Mason Canyon drainage has never been observed entering the Kendall pit. From the Kendall pit, the historic mainstem of the Mason Canyon drainage trends east through the current location of the CR Kendall plant, heap leach pads, ponds and other facilities. Springs are reported to be present beneath Leach Pad no. 4; however, these may be the result of excavation of native alluvium below the water table. Historical data indicate that historic tailings are present in some reaches of the drainage and are likely present from the process plant downstream to the mine permit boundary. CR Kendall reportedly removed portions of the historic tailings during facility construction. WMCI (1999) reported that hydrochemical data from surface water and pond samples collected in 1985 indicated elevated levels of iron, nitrate, and selenium prior to recent mining operations. The underdrain sump system for the process valley (TMW-26) has been incorporated into the pump-back system since 1996 (Photo 4). Monitoring wells in the Mason Canyon drainage are only completed though the shallow alluvium to the first bedrock unit encountered, No deep bedrock monitoring wells exist in this area of the mine site and flow and water quality in bedrock units in this area have not been evaluated.

Photo 4
Underdrain Sump Collector Well TMW-26 in Mason Canyon Drainage (Process Valley). View looking south July 24, 2003

5.6 South Fork of Last Chance Creek

The South Fork of Last Chance Creek is in the southernmost drainage that flows out of the CR Kendall mine permit area. The headwaters area is located at the Kendall waste dump and pit. The drainage flows southeast and empties into the pond located at the Boy Scout camp property. The geology in this drainage is markedly different that the other drainages in the mine area in that a large portion of the drainage in the mine area overlies Tertiary Syenite (Figure 7). Further downstream the drainage traverses the Kootenai Formation. Groundwater below the Kendall waste rock dump is collected by the pump-back system collector well KVPB-5. The mine began augmenting flow in the drainage in 2000.

Decreased flows from small springs located further south in the drainage have been reported and landowners have filed water rights violations with DNRC against the mine. Insufficient data exists to evaluate mine impacts to springs in this drainage; however, diminished flows in shallow spring systems can be expected as the result of long term drought conditions. Bedrock flow and water quality in this area have not been evaluated and only two shallow monitoring wells (TMW-31 and TMW-42) are present in the drainage below the Kendall waste rock dump.

Section 6
Summary

Site inspections were conducted as part of an overall review of hydrogeologic data for the CR Kendall Mine Closure EIS. Review of previous reports by Gallagher (2002) and WMCI (1999) indicate that mine-related water quality impacts are present in the shallow alluvium and springs east and south of the mine site. Recharge to these shallow flow systems is from snow melt and precipitation, some of which may have been interrupted by recent and historical mine operations. These drainages have historically (pre-drought) been described as ephemeral. Reduced precipitation over the last 10 years has been well documented and is likely the major component of reduced surface flows, lower groundwater levels, and hence the long-term reduced spring flows observed in these drainages. Test pits that were planned at the toe of the Muleshoe waste rock dump were not excavated because of the potential damage to the groundwater collection system for the pump-back system. These test pits were anticipated to provide detail of the waste rock and tailings/groundwater interaction on the hydrogeologic cross-sections for Little Dog Creek and Barnes King Gulch drainages. Monitoring wells installed through the waste rock and historic tailings would be useful to fill this data gap without damaging the collection system and could provide more detail for the hydrogeologic cross-sections provided in this draft report.

Monitoring of bedrock flow and water quality is sparse and limited to a few water supply wells. Flow paths are very complex due to the presence of lower permeability igneous intrusive units, karstic groundwater flow in the Madison Limestone, and large structural dips of sedimentary bedrock units flanking the North Moccasin Mountains. Dewatering of bedrock units has not taken place and the documented lack of water in mine pits during operations supports that little water quantity impact has occurred.

The mine pump-back groundwater capture system installed in 1996 has resulted in decreased groundwater flows in shallow alluvium below the mine site. The effectiveness of mine seepage capture by the systems cannot be quantitatively evaluated with the existing monitoring well network although water quality data provide some effectiveness monitoring information. Augmentation of surface water has been performed in the Little Dog Creek drainage by construction of a pipeline from Little Dog Spring east to the Section 29 Spring. Water supply wells also provide additional augmentation to the Section 29 Spring although there may be a risk of additional groundwater flow system impacts from pumping in bedrock units which lack flow path delineation. The mine pump-back system appears effective at reducing water quality impacts. The EIS will attempt to identify and evaluate effects of sequestration of metals in the irrigated areas.

Section 7
References

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